TENSAS RIVER TMDLS FOR DISSOLVED OXYGEN AND NUTRIENTS

May 28, 2002

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FOR DISSOLVED OXYGEN AND NUTRIENTS

SUBSEGMENT 081201

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources (NPS) discharging to the waterbody. This report presents TMDLs that have been developed for dissolved oxygen (DO) and nutrients for the Tensas River (subsegment 081201), in the Ouachita basin in northern Louisiana.

The Tensas River watershed covers approximately 1,006 mi^2 between the headwaters near Lake Providence, LA and the mouth at Jonesville, LA. In general, the watershed has little relief and the stream has a low gradient. The primary land use is agriculture, much of which is cropland. There are several small municipal point sources that discharge into tributaries of the Tensas River.

Subsegment 081201 was listed on the 1998 303(d) List for Louisiana as not fully supporting the designated use of propagation of fish and wildlife and was ranked as priority #2 for TMDL development. The causes for impairment cited in the 303(d) List included organic enrichment/low DO and nutrients. The water quality standard for DO is 5 mg/L year round for the subsegment.

A water quality model (LA-QUAL) was set up to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in the subsegment. The model was calibrated using intensive survey data collected by the Louisiana Department of Natural Resources (LDNR) during May 1979 and other various information obtained from the Louisiana Department of Environmental Quality (LDEQ) and the US Geological Survey (USGS). The projection simulation was run at critical flows and temperatures to address seasonality as required by the Clean Water Act. Reductions of NPS loads were required for the projection simulation to show the DO standard of 5 mg/L being maintained. In general, the modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures Manual.

A TMDL for oxygen demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand) was calculated using the results of the projection simulation. Both implicit and explicit margins of safety were included in the TMDL calculations. The nutrient TMDL was developed based on Louisiana's water quality standard for nutrients, which states that "the naturally occurring range of nitrogen to phosphorus ratios shall be maintained". The nutrient TMDL was calculated using allowable nitrogen loadings from the projection simulation and applying a naturally occurring nitrogen to phosphorus ratio to determine the allowable phosphorus loadings.

Several point sources were identified within subsegment 081201. Therefore, each TMDL for this subsegment includes a waste load allocation (WLA) for the point sources as well as a load allocation (LA) for NPS. In order to meet the DO standard of 5 mg/L along the entire length of the Tensas River, NPS loads will need to be reduced by approximately 93%. The permit limits used for the City of Tallulah WWTP were 10 mg/L BOD_5, 2 mg/L ammonia nitrogen, and 6 mg/L DO. Currently, the WWTP has a BOD_5 permit limit of 10 mg/L (monthly average), and monitoring requirements for ammonia nitrogen (but no limit).

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for dissolved oxygen (DO) and nutrients for the Tensas River, subsegment 081201. This subsegment was listed on the February 29, 2000 Modified Court Ordered 303(d) List for Louisiana (EPA 2000) as not fully supporting the designated use of propagation of fish and wildlife. The suspected sources and suspected causes for impairment in the 303(d) List are included in Table 1.1. Subsegment 081201 was ranked as priority #2 for TMDL development. The TMDLs in this report were developed in accordance with Section 303(d) of the Federal Clean Water Act and EPA's regulations at 40 CFR 130.7. The 303(d) Listings for other pollutants in this subsegment are being addressed by EPA and the Louisiana Department of Environmental Quality (LDEQ) in other documents.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern, and the LA is the load allocated to nonpoint sources (NPS). The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions, data inadequacies, and future growth.

Table 1.1. Summary of 303(d) Listing of subsegment 081201 (EPA 2000).

Subsegment Number	Waterbody Description	Suspected Sources	Suspected Causes	Priority Ranking (1 = highest)
081201	Tensas River	Agriculture Irrigated crop production Unknown source	Pesticides Organic enrichment/low DO Lead Nutrients Other inorganics Suspended solids Turbidity Salinity/TDS/chloride/sulfate	2

2.0 STUDY AREA DESCRIPTION

2.1 General Information

The Tensas River subsegment (081201) covers approximately 1,006 mi^2 in the Ouachita basin in northern Louisiana (see Figure A.1 in Appendix A). The headwaters begin near Lake Providence, LA and flow into Tensas Bayou, which becomes Tensas River in the vicinity of Tendal, LA (see Figure A.2 in Appendix A). The Tensas River flows generally southward to its confluence with the Black River at Jonesville, LA. In general, the watershed has little relief and the stream has a low gradient. As shown in Table 2.1, the primary land use in the Tensas River watershed is agriculture. Much of the agricultural land is cropland, some of which is irrigated.

Table 2.1. Land uses in subsegment 081201 based on GAP data (USGS 1998).

Land Use Type	% of Total Area
Fresh Marsh	0.5%
Saline Marsh	0.0%
Wetland Forest	19.7%
Upland Forest	0.0%
Wetland Scrub/Shrub	0.9%
Upland Scrub/Shrub	0.0%
Agricultural	72.0%
Urban	0.1%
Water	6.8%
Barren Land	0.0%
TOTAL	100.0%

2.2 Water Quality Standards

The numeric water quality standards and designated uses for this subsegment are shown in Table 2.2. The primary numeric standard for the TMDLs presented in this report is the DO standard of 5 mg/L year round.

Table 2.2. Water quality standards and designated uses (LDEQ 2000).

Subsegment Number	081201
Waterbody Description	Tensas River - Headwaters to Jonesville (including Tensas Bayou)
Designated Uses	ABC
Criteria:	
Chloride	45 mg/L
Sulfate	30 mg/L
DO	5 mg/L (year round)
pH	6.0-8.5
Temperature	32 °C
TDS	500 mg/L

USES: A – primary contact recreation; B – secondary contact recreation; C – propagation of fish and wildlife; D – drinking water supply; E – oyster propagation; F – agriculture; G – outstanding natural resource water; L – limited aquatic life and wildlife use.

For nutrients, there are no specific numeric criteria, but there is a narrative standard that states "The naturally occurring range of nitrogen-phosphorus ratios shall be maintained.... Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters." (LDEQ 2000).

In addition, LDEQ issued a declaratory ruling on April 29, 1996, concerning this language and stated, "That DO directly correlates with overall nutrient impact is a well-established biological and ecological principle. Thus, when the LDEQ maintains and protects DO, the LDEQ is in effect also limiting and controlling nutrient concentrations and impacts." DO serves as the indicator for the water quality criteria and for assessment of use support. For the TMDLs in this report, the nutrient loading required to maintain the DO standard is the nutrient TMDL.

2.3 Identification of Sources

2.3.1 Point Sources

A listing of all NPDES permits in the Ouachita and Calcasieu River basins was searched to identify any permits within the Tensas River subsegment (081201). This listing was prepared by EPA Region 6 using databases and permit files from LDEQ. Based on this listing, 14 NPDES permits were identified within subsegment 081201. Information for these 14 permits is shown in

Appendix B. Of these 14 permits, 7 of them were determined to have oxygen demanding discharges during critical conditions.

2.3.2 Nonpoint Sources

The nonpoint sources that were cited as suspected sources of impairment in the 303(d) List (Table 1.1) were agriculture and irrigated crop production.

2.4 Previous Data and Studies

Listed below are previous water quality data and studies in or near the Tensas River subsegment. The locations of the LDEQ ambient monitoring stations are shown on Figure A.2 in Appendix A.

1. Data collected by LDEQ for the "Tensas River at Tendal, LA" (Station 0066) for June 1958 to December 1990 (monthly) and February 1991 to April 1998 (bi-monthly).
2. Data collected by LDEQ for the "Tensas River at Clayton, LA" (Station 0159) for November 1988 to August 2001.
3. Data collected by LDEQ for the "Tensas River at Jonesville, LA" (Station 0799) for January 1999 to November 1999 (monthly).
4. Data collected by LDEQ for the "Tensas River southeast of Winnsboro, LA" (Station 0331) for February 1991 to April 1998 (bi-monthly).
5. Intensive survey of the Tensas River conducted by the Louisiana Department of Natural Resources (LDNR) on May 30, 1979. This survey included a total of 26 sampling locations on the Tensas River and selected tributaries. Data collected during this survey included temperature, DO, BOD_5, BOD_{20}, total Kjeldahl nitrogen (TKN), ammonia nitrogen, nitrate+nitrite nitrogen, and other parameters.

3.0 CALIBRATION OF WATER QUALITY MODEL

3.1 Model Setup

In order to evaluate the linkage between pollutant sources and water quality, a computer simulation model was used. The model used for these TMDLs was LA-QUAL (version 4.13), which was selected because it includes the relevant physical, chemical, and biological processes and it has been used successfully in the past for other TMDLs in Louisiana. The LA-QUAL model was set up to simulate organic nitrogen, ammonia nitrogen, ultimate carbonaceous biochemical oxygen demand (CBODu), and DO.

The main stem of the Tensas River (including Tensas Bayou) was divided into 6 reaches to represent varying depths and widths along the stream (see Figure A.3 in Appendix A). Of the 7 oxygen demanding point source discharges in the Tensas River subsegment (see Section 2.3.1), only 1 discharge was included in the model (the City of Tallulah wastewater treatment plant (WWTP)). The other 6 oxygen demanding discharges were included in the TMDL calculations but were not explicitly modeled because their impact on the main stem of the Tensas River was considered to be negligible due to their distance from the main stem. In order to include the City of Tallulah WWTP in the model, a branch was added to simulate the tributaries through which the effluent flows to get to the main stem (Panola Bayou, Mothiglam Bayou, and Alligator Bayou). This branch was divided into 2 reaches to represent varying widths and depths. Inflows from the significant tributaries to the Tensas River were also included in the model as shown in Figure A.3.

3.2 Calibration Period

The 3 data sets that were evaluated for use as a calibration data set were the 1979 LDNR intensive survey, routine ambient monitoring data collected by LDEQ at several locations, and data from a synoptic survey of the study area performed by FTN in August 2001. These 3 data sets are summarized in Appendix C. Neither the LDEQ routine monitoring data nor the FTN synoptic survey had data for more than 4 sites within the subsegment, but the LDNR intensive survey had data for 26 sites. Also, the LDEQ routine monitoring data did not include any BOD and included only limited ammonia nitrogen data collected at 2 sites during 1999-2000. The LDNR intensive survey data included temperature, DO, BOD_5, BOD_{20}, TKN, ammonia nitrogen, nitrate+nitrite nitrogen, and other parameters.

The LDNR intensive survey provided the most complete data set based on the number of sites and parameters that were reported. Therefore, the model was calibrated to conditions during the LDNR intensive survey on May 30, 1979.

3.3 Temperature Correction of Kinetics (Data Type 4)

The temperature correction factors used in the model were consistent with the Louisiana Technical Procedures Manual (the "LTP"; LDEQ 2001). These correction factors were:

• Correction for BOD decay:	1.047 (value in LTP is same as model default)
• Correction for SOD:	1.065 (value in LTP is same as model default)
• Correction for ammonia N decay:	1.070 (specified in Data Group 4)
• Correction for organic N decay:	1.020 (not specified in LTP; model default used)
• Correction for reaeration:	automatically calculated by the model

3.4 Hydraulics (Data Type 9)

The hydraulics were specified in the input for the LA-QUAL model using the power functions (width = a * Q^b + c and depth = d * Q^e + f). The exponents for the power functions (b and e) were based upon log-log regressions of data from individual discharge measurements made by USGS personnel at the gaging station on the Tensas River near Tendal (07369500). These data are shown in Appendix D and consist of width, cross sectional area, and mean velocity for individual discharge measurements that were taken over a wide range of flows for developing and maintaining a rating curve. Mean depth for each discharge measurement was calculated as cross sectional area divided by width. Plots of width, depth, and velocity versus flow were developed in a spreadsheet and trendlines were put on the plots to show the regression results. These plots and regression results are shown in Appendix D.

The coefficients for the power functions (a and d) were back-calculated by estimating the actual widths, depths, and flows (Q) and solving for the coefficients assuming that the constants (c and f) are zero. The actual widths were estimated from aerial photographs (digital ortho quarter quads) and the actual depths were estimated from scattered measurements of depth in the middle of the channel taken during the LDNR intensive survey. The flows were estimated based on USGS flow data for May 30, 1979 for the Tensas River at Tendal and Bayou Macon at Delhi. A spreadsheet summarizing these calculations is shown in Appendix D. Model input values for the calibration are shown in Appendix E.

3.5 Initial Conditions (Data Type 11)

Because temperature is not being simulated in the model, temperature for each reach was specified in the initial conditions for LA-QUAL. The temperature for each reach was set to the average of temperatures measured at stations within the reach during the 1979 intensive survey. Because no temperature measurements were made in Panola Bayou or Mothiglam Bayou, the initial temperatures for those reaches were set to the temperature used for reach 1 (based on similar depths). The input data and sources are shown in Appendix E.

For constituents not being simulated, the initial concentrations were set to zero; otherwise, the model would have assumed a fixed concentration of those constituents and the model would have included the effects of the unmodeled constituents on the modeled constituents (e.g., the effects of algae on DO).

3.6 Water Quality Kinetics (Data Types 12 and 13)

Kinetic rates used in LA-QUAL include reaeration rates, CBOD decay rates, nitrification rates, and mineralization rates (organic nitrogen decay). The values used in the model input are shown in Appendix E.

For reaeration, the Louisiana Equation (option 15) was specified in the model because it was developed specifically for streams in Louisiana and it has been used successfully in the past for other TMDLs in Louisiana.

The rates for CBOD decay and nitrification (ammonia nitrogen "decay") were based on median values of laboratory decay rates from LDEQ's long term BOD analyses. The LDEQ long term BOD analyses consisted of 140 samples from intensive surveys in the Ouachita River basin during 2001. The median decay rates for CBOD and nitrogenous biochemical oxygen demand (NBOD) were approximately 0.06/day and 0.07/day, respectively. These data are shown in Appendix F. Because instream decay rates are typically slightly higher than laboratory decay rates, both the CBOD decay rates and the nitrification rates were set to 0.10/day for all reaches.

The mineralization rates (organic nitrogen decay) in the model were set to 0.02/day for all reaches. This value was similar to the values shown in Table 5.3 of the "Rates, Constants, and Kinetics" publication (EPA 1985) for dissolved organic nitrogen being transformed to ammonia nitrogen. The literature values for mineralization rates are shown in Appendix G.

One other input value was specified for characterizing the nitrification process. In the program constants section of the model input file (data type 3), the nitrification inhibition option was set to 1 instead of the default of option number 2. With the default option, the nitrification rate drops rapidly when the DO drops below 2 mg/L, which results in an unrealistic build up of ammonia nitrogen at low DO. Option number 1 provides nitrification inhibition that is similar to what is used in other water quality models such as QUAL2E and WASP (see Figure 3.5 in FTN 2000).

3.7 Nonpoint Source Loads (Data Type 19)

The NPS loads that are specified in the model can be most easily understood as resuspended load from the bottom sediments and are modeled as SOD, benthic ammonia source rates, CBOD loads, and organic nitrogen loads. The SOD (specified in data type 12), the benthic ammonia source rates (specified in data type 13), and the mass loads of organic nitrogen and CBODu (specified in data type 19) were all treated as calibration parameters; their values were adjusted until the model output was similar to the calibration target values. The values used as model input are shown in Appendix E.

These four calibration parameters were adjusted in a specific order based on the interactions between state variables in the model. First, the organic nitrogen loads were adjusted until the predicted organic nitrogen concentrations were similar to the observed concentrations. Organic nitrogen was calibrated first because none of the other state variables will affect the organic nitrogen concentrations. Next, the benthic ammonia source rates were adjusted until the predicted ammonia nitrogen concentrations were similar to the observed concentrations. Then the CBODu loads were adjusted until the predicted CBODu concentrations were similar to the observed concentrations. Finally, the SOD rates were adjusted until the predicted DO concentrations were similar to the observed concentrations. The DO was calibrated last because all of the other state variables affect DO.

3.8 Headwater, Tributary, and Incremental Flow Rates (Data Types 16, 20, and 24)

Inflow rates for the Tensas River were based on the USGS daily flow data for the Tensas River at Tendal (07369500) and Bayou Macon at Delhi (07370000) on May 30, 1979. Based on the flow per square mile of drainage area for the Tensas River gage, flows at the upstream and downstream ends of the subsegment were calculated using published drainage areas for Tensas River (USGS 1971). The flows for all tributaries except Bayou Macon were also calculated by multiplying the flow per unit area from the Tensas River by the estimated drainage area for each tributary. The headwater flow for Panola Bayou was calculated in the same way (using the Tensas River flow per unit area). The inflow for Bayou Macon was estimated by multiplying the flow per square mile of drainage area for the USGS gage on Bayou Macon by the published drainage area for the mouth of Bayou Macon (USGS 1971). The incremental inflow was then estimated as the total flow at the downstream end of the subsegment minus the sum of all of the headwater and tributary inflows. This total amount of incremental inflow was assumed to be uniformly distributed along the entire length of the channels being model; therefore, the incremental inflow for each reach was proportional to its length. The drainage area information and inflow calculations are shown in Appendix H. Model input values are shown in Appendix E.

3.9 Headwater, Tributary, and Incremental Water Quality (Data Types 16, 17, 20, 21, 24, and 25)

Concentrations of DO, CBODu, organic nitrogen, ammonia nitrogen, and nitrate + nitrite nitrogen were specified in the model for the headwater, tributary, and incremental inflows. Water quality for these inflows was based on water quality data collected during the LDNR intensive survey. The values used as model input are shown in Appendix E.

3.10 Point Source Inputs

Because effluent data were not collected for the City of Tallulah WWTP during the LDNR intensive survey, model inputs for this discharge were based on the current NPDES permit. Although the design flow and level of treatment for the WWTP have probably changed since 1979, there are no data to indicate what the effluent characteristics were in 1979.

The flow rate for the WWTP was set to the design flow. The CBODu concentration was set to the BOD_5 permit limit times 2.3 to convert to CBODu. The ammonia nitrogen concentration was based on the BOD_5 permit limit and typical combinations of BOD_5 and ammonia nitrogen listed in the LTP. The organic nitrogen concentration was assumed to be half of the ammonia nitrogen concentration based on typical values for mechanical treatment systems. Nitrate+nitrate nitrogen was set to the EPA criteria for drinking water (10 mg/L). The values used as model input are shown in Appendix E.

3.11 Model Results for Calibration

Plots of predicted and observed water quality for the calibration are presented in Appendix I and a printout of the LA-QUAL output file is included as Appendix J. The calibration was considered to be acceptable based on the amount of data that were available.

4.0 WATER QUALITY MODEL PROJECTION

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Therefore, the calibrated model was used to project water quality for critical conditions. The identification of critical conditions and the model input data used for critical conditions are discussed below.

4.1 Identification of Critical Conditions

Section 303(d) of the Federal Clean Water Act and EPA's regulations at 40 CFR 130.7 both require the consideration of seasonal variation of conditions affecting the constituent of concern and the inclusion of a MOS in the development of a TMDL. For the TMDLs in this report, analyses of LDEQ long-term ambient data were used to determine critical seasonal conditions. A combination of implicit and explicit MOS was used in developing the projection model.

Critical conditions for DO have been determined for Louisiana waterbodies in previous TMDL studies. The analyses concluded that the critical conditions for stream DO concentrations occur during periods with negligible nonpoint runoff, low stream flow, and high stream temperature.

When the rainfall runoff (and nonpoint loading) and stream flow are high, turbulence is higher due to the higher flow and the stream temperature is lowered by the cooler precipitation and runoff. In addition, runoff coefficients are higher in cooler weather due to reduced evaporation and evapotranspiration, so that the high flow periods of the year tend to be the cooler periods. DO saturation values are, of course, much higher when water temperatures are cooler, but BOD decay rates are much lower. For these reasons, periods of high loading are periods of higher reaeration and DO but not necessarily periods of high BOD decay.

LDEQ interprets this phenomenon in its TMDL modeling by assuming that the annual nonpoint loading, rather than loading for any particular day, is responsible for the accumulated benthic blanket of the stream, which is, in turn, expressed as SOD and/or resuspended BOD in the model. This accumulated loading has its greatest impact on the stream during periods of higher temperature and lower flow.

According to the LTP, critical summer conditions in DO TMDL projection modeling are simulated by using the annual 7Q10 flow or 0.1 cfs, whichever is higher, for all headwaters, and 90th percentile temperature for the summer season. For the Tensas River TMDL, model loading is from perennial tributaries, point sources, SOD, and resuspension of sediments.

In reality, the highest temperatures occur in July-August and the lowest stream flows occur in October-November. The combination of these conditions plus the impact of other conservative assumptions regarding rates and loadings yields an implicit MOS that is not quantified. Over and above this implicit MOS, an explicit MOS of 10% for NPS and 20% for point sources was incorporated into the TMDLs in this report to account for model uncertainty.

4.2 Temperature Inputs

The LTP (LDEQ 2001) specifies that the critical temperature should be determined by calculating the 90th percentile seasonal temperature for the waterbody being modeled. Long term temperature data from the Tensas River at Tendal (LDEQ station 0066) were used to calculate a 90th percentile summer temperature of 30.0EC. This value was specified in data type 11 in the model and is shown in Appendix K. The 90th percentile calculations are shown in Appendix L.

Because the Tensas River has a year round standard for DO, a winter projection simulation was not performed. As discussed above, the most critical time of year for meeting a constant DO standard is the period of high temperatures and low flows (i.e., summer).

4.3 Headwater, Tributary, and Incremental Inputs

The inputs for the headwaters and tributaries for the projection simulation were based on guidance in the LTP. As specified in the LTP, the DO concentration for the headwater and tributary inflow was set to 90% saturation at the critical temperature. Headwater and tributary concentrations for other parameters were kept the same as in the calibration simulation.

Published 7Q10 values were available for the Tensas River at Tendal (07369500) and Bayou Macon near Delhi (07370000). The published 7Q10 flows are 4.3 cfs for the Tensas River gage and 22 cfs for the Bayou Macon gage (Lee 2000). The headwater and tributary flow rates in the projection simulation were estimated by developing a 7Q10 flow per unit area for the Tensas River gage and multiplying it by the drainage area for each headwater. This procedure yielded 7Q10 flow rates of 1.49 cfs for the Tensas River headwater and 0.44 cfs for the Panola Bayou headwater. Because the LTP specifies that the critical flow rate should be set to the 7Q10 flow or 0.1 cfs, whichever is higher, these estimated 7Q10 values were used as model input for the headwaters.

The 7Q10 flow rates for the tributaries other than Bayou Macon were also estimated from the 7Q10 flow per unit area for the Tensas River at Tendal gage. The 7Q10 flow for Bayou Macon was estimated using the 7Q10 flow per unit area for the Bayou Macon at Delhi gage. Incremental inflow was set to zero in the projection simulation. The values used as model input in the projection simulation are shown in Appendix K. The published 7Q10 information is included as Appendix M.

4.4 Point Source Inputs

For the City of Tallulah WWTP, the flow was set to 1.25 times the current design flow in order to incorporate an explicit 20% margin of safety. The CBODu concentration was unchanged from the calibration, but the ammonia nitrogen concentration was reduced from 5 mg/L to 2 mg/L to avoid ammonia toxicity. The values used as model input for the projection simulation are shown in Appendix K.

4.5 Nonpoint Source Loads

Because the initial projection simulation was showing low DO values in all of the reaches, the NPS loadings were reduced until all of the predicted DO values were equal to or greater than the water quality standard of 5.0 mg/L. The same percent reduction was applied to all components of the NPS loads (SOD, benthic ammonia source rates, and mass loads of CBODu and ammonia nitrogen). The values used as model input in the projection simulation are shown in Appendix K.

4.6 Other Inputs

The only model inputs that were changed from the calibration to the projection simulation were the inputs discussed above in Sections 4.2 through 4.5. Other model inputs (e.g., hydraulic coefficients, decay rates, reaeration equations, etc.) were unchanged from the calibration simulation.

4.7 Model Results for Projection

Plots of predicted water quality for the projection are presented in Appendix N and a printout of the LA-QUAL output file is included as Appendix O.

A NPS load reduction of approximately 93% was required to bring the predicted DO values to at least 5.0 mg/L for all reaches. The permit limits used for the City of Tallulah WWTP were 10 mg/L BOD_5, 2 mg/L ammonia nitrogen, and 6 mg/L DO. Currently, the WWTP has a BOD_5 permit limit of 10 mg/L (monthly average), and monitoring requirements for ammonia nitrogen (but no limit).

The percentage reduction for NPS loads mentioned above represents a percentage of the entire NPS loading, not a percentage of the manmade NPS loading. The NPS loads in this report were not divided between natural and manmade because it would be difficult to estimate natural NPS loads for the study area.

5.0 TMDL CALCULATIONS

5.1 DO TMDL

A total maximum daily load (TMDL) for DO has been calculated for the Tensas River subsegment based on the results of the projection simulation. The DO TMDL is presented as oxygen demand from CBODu, organic nitrogen, ammonia nitrogen, and SOD. A summary of the loads for the Tensas River is presented in Table 5.1.

The TMDL calculations were performed using a FORTRAN program that was written by FTN personnel. This program reads two files; one is the LA-QUAL output file from the projection simulation and the other is a small file with miscellaneous information needed for the TMDL calculations (shown in Appendix P). The output from the program is shown in Appendix Q and the source code for the program is shown in Appendix R.

Table 5.1. DO TMDL for subsegment 081201 (Tensas River).

	Oxygen demand (kg/day) from:				**Total oxygen demand (kg/day)**
	CBODu	**Organic N**	**Ammonia N**	**SOD**	
WLA for City of Tallulah	222.57	41.90	83.80	NA	348.27
WLA for minor point sources	114.09	265.24	132.62	NA	511.95
MOS for all point sources	84.17	76.79	54.11	NA	215.07
LA for NPS	3717.05	539.86	24.65	2360.90	6642.46
MOS for NPS	413.01	59.98	2.74	262.32	738.05
TMDL	4550.89	983.77	297.92	2623.22	8455.80

The oxygen demand from organic nitrogen and ammonia nitrogen was calculated as 4.33 times the nitrogen loads (assuming that all organic nitrogen is eventually converted to ammonia). The value of 4.33 is the same ratio of oxygen demand to nitrogen that is used by the LA-QUAL model. For the SOD loads, a temperature correction factor was included in the calculations (in order to be consistent with LDEQ procedures).

The WLA for minor point sources represents the combined loadings from the 6 oxygen demanding point sources that were identified in Section 2.3.1 but not included in the model due to their small size and distance from the main stem of the Tensas River. Information for these point sources is shown in Appendix B. The WLA for these minor point sources was calculated based on current permit limits with no load reductions.

5.2 Nutrient TMDL

As discussed in Section 2.2, Louisiana has no numeric standards for nutrients, but has a narrative standard that states that “the naturally occurring range of nitrogen-phosphorus ratios shall be maintained” (LDEQ 2000). For these TMDLs, nutrients were defined as total nitrogen (organic nitrogen plus ammonia nitrogen plus nitrate/nitrite nitrogen) and total phosphorus. The value used for the naturally occurring nitrogen to phosphorus ratio was 8.0. This ratio was based on LDEQ reference stream data for the Upper Mississippi Alluvial Plain ecoregion (Smythe 1999). These data are shown in Appendix S.

The first step in calculating the nutrient TMDL was to determine the loads of total nitrogen (TN) that were simulated in the projection model. The loads in the projection model represent the maximum allowable loads that will maintain DO standards. Then the allowable loads of total phosphorus (TP) were calculated by dividing the nitrogen loads by the naturally occurring ratio of TN to TP. The resulting loads of TN and TP for the Tensas River subsegment are presented in Table 5.2.

Table 5.2. Nutrient TMDL for subsegment 081201 (Tensas River).

	Organic N (kg/day)	**Ammonia N (kg/day)**	**NO_2 + NO_3 (kg/day)**	**Total N (kg/day)**	**Total P (kg/day)**
WLA for City of Tallulah	9.68	19.35	96.77	125.80	15.72
WLA for minor point sources	61.26	30.63	31.25	123.14	15.39
MOS for all point sources	17.73	12.50	32.00	62.23	7.78
LA for NPS	124.68	5.69	78.82	209.19	26.15
MOS for NPS	13.85	0.63	8.76	23.24	2.91
TMDL	227.20	68.80	247.60	543.60	67.95

5.3 Ammonia Toxicity Calculations

Although subsegment 081201 is not on a 303(d) List for ammonia, the ammonia concentrations predicted by the projection model were checked to make sure that they did not exceed EPA criteria for ammonia toxicity (EPA 1999). The EPA criteria are dependent on temperature and pH. The water temperature used to calculate the ammonia toxicity criterion for Tensas River was the same as the critical temperature used in the projection simulation (30.0°C). The pH values used in these calculations was an average of the values measured during the summer period (May-October) at LDEQ station 0066 during the last 10 years. The resulting criterion was 2.0 mg/L of ammonia nitrogen. The instream ammonia nitrogen concentrations predicted by the LA-QUAL model were all below the criterion. This indicates that the ammonia nitrogen loadings that will maintain the DO standard are low enough that the EPA ammonia toxicity criteria will not be exceeded under critical conditions. The ammonia toxicity calculations are shown in Appendix T.

5.4 Summary of Load Reductions

In summary, the projection modeling used to develop the TMDLs above showed that NPS loads need to be reduced by approximately 93% to maintain the DO standard along the entire length of the Tensas River. The permit limits used for the City of Tallulah WWTP were 10 mg/L BOD_5, 2 mg/L ammonia nitrogen, and 6 mg/L DO. Currently, the WWTP has a BOD_5 permit limit of 10 mg/L (monthly average), and monitoring requirements for ammonia nitrogen (but no limit).

5.5 Seasonal Variation

As discussed in Section 4.1, critical conditions for DO in Louisiana waterbodies have been determined to be when there is negligible nonpoint runoff and low stream flow combined with high water temperatures. In addition, the model accounts for loadings that occur at higher flows by modeling sediment oxygen demand. Oxygen demanding pollutants that enter the waterbodies during higher flows settle to the bottom and then exert the greatest oxygen demand during the high temperature seasons.

5.6 Margin of Safety

The MOS accounts for any lack of knowledge or uncertainty concerning the relationship between load allocations and water quality. As discussed in Section 4.1, the highest temperatures occur in July through August, the lowest stream flows occur in October through November, and the maximum point source discharge occurs following a significant rainfall, i.e., high-flow conditions. The combination of these conditions, in addition to other conservative assumptions regarding rates and loadings, yields an implicit MOS which is not quantified. In addition to the implicit MOS, the TMDLs in this report include an explicit MOS of 10% for NPS loads and 20% for point source loads.

6.0 SENSITIVITY ANALYSES

All modeling studies necessarily involve uncertainty and some degree of approximation. It is therefore of value to consider the sensitivity of the model output to changes in model coefficients, and in the hypothesized relationships among the parameters of the model. The sensitivity analyses were performed by allowing the LA-QUAL model to vary one input parameter at a time while holding all other parameters to their original value. The calibration simulation was used as the baseline for the sensitivity analysis. The percent change of the model's minimum DO projections to each parameter is presented in Table 6.1. Each parameter was varied by "30%, except for temperature, which was varied "2ºC.

Values reported in Table 6.1 are sorted by percentage variation of minimum DO from smallest percentage variation to largest. The parameters to which DO was most sensitive were reaeration, depth, SOD, temperature, BOD decay rate, and wasteload flow.

Table 6.1. Summary of results of sensitivity analyses.

Input Parameter	Parameter Change	Predicted minimum DO (mg/L)	Percent Change in Predicted DO (%)
Baseline	-	1.78	-
Waste Load DO	-30%	1.78	< 1
Waste Load DO	+30%	1.78	< 1
Waste Load NH_3	-30%	1.78	< 1
Waste Load NH_3	+30%	1.78	< 1
NH_3 decay rate	-30%	1.78	< 1
NH_3 decay rate	+30%	1.78	< 1
Organic N decay rate	-30%	1.78	< 1
Organic N decay rate	+30%	1.78	< 1
Waste Load Organic N	-30%	1.78	< 1
Waste Load Organic N	+30%	1.78	< 1
Waste Load BOD	-30%	1.80	1
Waste Load BOD	+30%	1.76	1
Headwater flow	-30%	1.76	1
Headwater flow	+30%	1.80	1
SOD	+30%	1.64	8
BOD decay rate	+30%	1.62	9
Initial Temperature	+2EC	1.62	9
Waste Load flow	-30%	1.62	9
Waste Load flow	+30%	2.04	15
BOD decay rate	-30%	2.14	20
Depth	+30%	1.34	25
Initial Temperature	-2EC	2.23	26
Reaeration	-30%	1.29	28
SOD	-30%	2.55	44
Reaeration	+30%	2.98	68
Depth	-30%	3.26	83

Note: "Waste Loads" represent both tributaries and point source discharges.

7.0 OTHER RELEVANT INFORMATION

This TMDL has been developed to be consistent with the antidegradation policy in the LDEQ water quality standards (LAC 33:IX.1109.A).

Although not required by this TMDL, LDEQ utilizes funds under Section 106 of the Federal Clean Water Act and under the authority of the Louisiana Environmental Quality Act to operate an established program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (Water Quality Inventory) and the 303(d) List of impaired waters. This information is also utilized in establishing priorities for the LDEQ NPS program.

The LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a five-year cycle with two targeted basins sampled each year. Long-term trend monitoring sites at various locations on the larger rivers and Lake Pontchartrain are sampled throughout the five-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second five-year cycle. This will allow the LDEQ to determine whether there has been any improvement in water quality following establishment of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) List. The sampling schedule for the first five-year cycle is shown below. The Ouachita River Basin will be sampled again in 2004.

1998 – Mermentau and Vermilion-Teche River Basins
1999 – Calcasieu and Ouachita River Basins
2000 – Barataria and Terrebonne Basins
2001 – Lake Pontchartrain Basin and Pearl River Basin
2002 – Red and Sabine River Basins

(Atchafalaya and Mississippi Rivers will be sampled continuously.)

In addition to ambient water quality sampling in the priority basins, the LDEQ has increased compliance monitoring in those basins, following the same schedule. Approximately 1,000 to 1,100 permitted facilities in the priority basins were targeted for inspections. The goal set by LDEQ was to inspect all of those facilities on the list and to sample 1/3 of the minors and 1/3 of the majors.

8.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, 40 CFR §130.7(d)(2) requires EPA to publicly notice and seek comment concerning the TMDL. Pursuant to an October 1, 1999 Court Order, this TMDL was prepared under contract to EPA. After development of the draft of this TMDL, EPA commenced preparation of a notice seeking comments, information, and data from the general and affected public. Comments and additional information were submitted during the public comment period and this TMDL was revised accordingly. Responses to these comments and additional information are included in Appendix U. EPA has transmitted this revised TMDL to LDEQ for incorporation into LDEQ's current water quality management plan.

9.0 REFERENCES

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APPENDIX A THROUGH T AVAILABLE THROUGH EPA UPON REQUEST

APPENDIX U

Responses to Comments

COMMENTS AND RESPONSES
TENSAS RIVER TMDLs FOR DO AND NUTRIENTS
May 28, 2002

EPA appreciates all comments concerning these TMDLs. Comments that were received are shown below with EPA responses or notes inserted in a different font.

GENERAL COMMENTS FROM LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY (LDEQ):

Note: LDEQ submitted one document containing comments on 98 TMDLs for various pollutants and subsegments throughout the Ouachita and Calcasieu basins. Only the portions of that comment document that apply to the DO and nutrient TMDLs in the Ouachita basin (10 subsegments) are shown below. Some of the general comments may not apply to this report.

The Louisiana Department of Environmental Quality hereby submits comments on the 98 TMDLs and the calculations for these TMDLs prepared by EPA Region 6 for waters listed in the Calcasieu and Ouachita river basins, under section 303(d) of the Clean Water Act. Listed below are general comments.

1. Many of these TMDLs are based on models using historical water quality data gathered at a single or small number of locations rather than survey data gathered at sites spaced throughout the waterbody. The hydraulic information used was generally an average value or estimated value, not taken at the same time as the water quality data. The calibrations are inadequate due to the lack of appropriate hydrologic data and the paucity of water quality data. The resulting TMDLs are invalid. LDEQ does not accept these TMDLs.

Response: The TMDLs were based on existing data plus information that could be obtained with available resources. Each model was developed using the most appropriate hydraulic information and water quality data that were available. A rationale was provided for data use and assumptions and limitations were given. Although LDEQ typically collects more data for model calibration than what was available for calibration of most of these models, EPA considers these model calibrations and the resulting TMDLs to be valid.

2. LDEQ does not consider any of these waters to be impaired due to low dissolved oxygen, nutrients, or ammonia. Many of these waters simply have inappropriate standards and criteria. The resources spent on developing these TMDLs could have been far more effectively and wisely spent on reviewing, approving, and assisting in the development of appropriate standards and criteria for these waters through the UAA process.

Response: TMDLs were developed for these subsegments based on the requirements of Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 and the suspected causes of impairment (organic enrichment/low DO and/or nutrients) for each subsegment in the EPA Modified Court Ordered 303(d) List. TMDLs must be established to meet existing water quality standards. If it is determined that a standards changes is appropriate, the TMDL can be revised to reflect that change.

3. CBODu and NH3-N were estimated from surrogate parameters rather than actual measured data for most of the TMDLs. The TMDL report uses the LDEQ's multi-basin loading database's median ratio values between the ultimate loads and the proposed surrogates. This data was based on the measured data from the last two years of LDEQ water quality surveys. LDEQ objects to the correlation of TOC to CBOD and NH3-N to TKN unless these correlations are taken from water quality data on the modeled waterbody. Our studies have shown only a moderate correlation between these parameters within the same waterbody, however when this correlation was attempted across waterbodies, extreme variability was seen and the correlations were not judged valid. It is possible that a combination of surrogates will obtain a better correlation, such as TOC along with color, turbidity, pH, etc. LDEQ is currently researching these options.

Response: EPA agrees that it would be ideal to have data collected from each modeled waterbody for relating TOC to CBOD and NH3-N to TKN. However, none of these subsegments had sufficient data from which these relationships could be developed. Relationships with surrogate parameters were used only when data for the desired parameter was not available.

4. BOD decay rates were estimated from surrogate parameters rather than actual measured data for most of the TMDLs. The TMDL report uses the LDEQ's multi-basin loading database's median values. This data was based on the measured data from the last two years of LDEQ water quality surveys. It has been LDEQ's experience that these rates vary significantly from waterbody to waterbody and frequently vary significantly within the same waterbody. LDEQ objects to using surrogate data without regard for specific waterbody conditions for these parameters.

Response: Due to the schedule and level of resources available for this project, it was not feasible to perform long term BOD time series analyses on samples from these waterbodies. Given this situation, using LDEQ’s database was considered the best approach for estimating decay rates.

5. A winter projection model was not developed for most of the TMDLs. Winter projection models must be developed to address seasonality requirements of the Clean Water Act. Where point sources have seasonally variable effluent limitations or such seasonal variations are proposed, a winter projection model is required to show that standards are met year-round.

Response: As discussed in Section 4.2 of each report, summer is the most critical season for meeting the year round standard for DO for these subsegments. Therefore, the summer simulation satisfies the seasonality requirements of the Clean Water Act. The available information for point source discharges indicated that the facilities discharging to these waterbodies do not have seasonal permit limits. If any of these facilities wishes to pursue seasonal permit limits, then LDEQ or the permittee can re-run the model to develop seasonal wasteload allocations.

6. LDEQ takes exception to the calculation of a TMDL based on TN/TP ratios derived from waterbodies other than the modeled waterbody. It is LDEQ's experience that the natural allowable TN/TP ratio is waterbody-specific and can vary dramatically between streams.

Response: These nutrient TMDLs were developed using naturally occurring ratios of nitrogen to phosphorus based on Louisiana's narrative water quality standard for nutrients. These ratios were calculated using reference stream data rather than long term monitoring data for each subsegment because the reference stream data were considered to be more appropriate for naturally occurring conditions.

7. LDEQ has not adopted the EPA recommended ammonia criteria (1999) and takes exception to its use in these TMDLs. In general, LDEQ does not accept EPA's use of national guidance for TMDL endpoints. The nationally recommended criteria do not consider regional or site- specific conditions or species and may be inappropriately over protective or under protective. No ammonia nitrogen toxicity has been demonstrated or documented in any of the waterbodies in these TMDLs. The general criteria (in particular, LAC 33:IX.1113.B.5) require state waters be free from the effects of toxic substances.

Response: Ammonia toxicity calculations were performed to ensure that the ammonia loadings that will maintain DO standards will not cause any exceedences of the ammonia toxicity criteria. National guidance for ammonia toxicity was used in the absence of any numerical state water quality standards for ammonia. EPA believes that this evaluation offers assurances that waters will continue to be free from the effects of toxic substances.

8. Algae were not simulated. Was there evidence that algae did not have an impact on the waterbody? Did the contractor have any Chlorophyll a measurements on which to base this determination?

Response: For most of these subsegments, the effects of algae were not simulated in the models because there were no data to clearly demonstrate a need for including algae and the models calibrated well without including algae (i.e., the models were calibrated without having to use unreasonable coefficients to compensate for algal effects).

SPECIFIC COMMENTS FROM LDEQ FOR TENSAS RIVER:

1. This model was calibrated to data obtained primarily from an LDNR study that was conducted on May 30, 1979. This data is outdated and does not coincide with LDEQ assessments, which are limited to the last five years of data. The calibration is inadequate.

Response: As discussed in Section 3.2 of the report, the 1979 data set was chosen for calibration because it included data collected at numerous sites along the length of the stream and some hydraulic information was collected at the same as the water quality data were collected. Both of these criteria for selecting a calibration data set are used by LDEQ (as noted in General Comment No. 1 above). Because the stream is dominated by nonpoint sources (rather than point sources that would be upgraded over the years), it is likely that the coefficients for instream processes have not changed significantly since 1979.